SURFACE WATER SAMPLING WORKPLAN
QUALITY ANALYTICAL SERVICES
1633 Marsh Avenue
Blue Summit, MO

Project: 843876

August 2, 2004

Prepared for:

Deffenbaugh Industries, Inc.
P. O. Box 3220
Shawnee, KS 66203

Prepared by:

Shaw Environmental, Inc.
4400 College Boulevard, Suite 350
Overland Park, Kansas 66211

Written by:

Michael J. Kirby, PG
Hydrogeologist
Shaw Environmental, Inc.

Reviewed by:

Philip C. Dula, PG, CHHM
Senior Project Manager
Shaw Environmental, Inc.

STATE OF MISSOURI
MARK FINNEY
7/5/04
RG0785
REGISTERED GEOLOGIST

DEFFENBAUGH
INDUSTRIES

August 3, 2004

FILE COPY

Mrs. Darleen Groner, P.E.
Missouri Department of Natural Resources
Hazardous Waste Program
P.O. Box 176
Jefferson City, MO 65102

Re: Administrative Order on Consent for Corrective Action #VII-94-H-0024 (AOC) and the RCRA Facility Investigation (RFI) at Quality Analytical Services (QAS)

Dear Mrs. Groner:

A work plan for the collection of surface water and sediment samples from the oxbow of the Blue River, located west of our facility, has been prepared by Shaw Environmental, Inc. and is being submitted for your review and approval. This data is required to assist in the completion of a Human Health and Environment Risk Assessment (HHRA) for our site. This detailed work plan has been prepared in partial response to the MDNR correspondence dated July 14, 2004. Shaw Environmental, Inc. is currently in the process of completing revisions in the HHRA which will address the balance of comments offered in that letter.

It is our plan to accelerate the schedule for the fall groundwater sampling event to coincide with the sampling activity proposed in this work plan. A copy of the work plan is also being submitted to Mr. David Garrett, of the USEPA, for his concurrent review and approval. He has expressed interest in utilizing the results obtained from this activity to assist in the evaluation of Environmental Indicators (EI) relative to groundwater impacts at this site. We believe we can be ready to collect the samples within two weeks of the joint approval of this plan. Thank you in advance for your effort in expediting the review and approval process.

Sincerely,

James M. Cossairt

James M. Cossairt
Senior Project Geologist

c: David Garrett, EPA Region VII
Adam Larky, Shaw Environmental, Inc., Livonia MI
Phil Dula, Shaw Environmental, Inc., Overland Park, KS

DEFFENBAUGH
INDUSTRIES

FILE COPY

August 9, 2004

Mrs. Darleen Groner, P.E.
Missouri Department of Natural Resources
Hazardous Waste Program
P.O. Box 176
Jefferson City, MO 65102

Re: Administrative Order on Consent for Corrective Action #VII-94-H-0024 (AOC) and the RCRA Facility Investigation (RFI) at Quality Analytical Services (QAS)

Dear Mrs. Groner:

Enclosed are an updated title page and notebook cover for the surface water and sediment sampling work plan which was submitted for review and approval last week. These pages have now been sealed by a registered geologist in the state of Missouri. Copies of these pages have also been mailed to David Garrett for inclusion in his copy of the document. I apologize for any inconvenience.

Sincerely,

James M. Cossairt

James M. Cossairt
Senior Project Geologist

c: David Garrett, EPA Region VII
Adam Larky, Shaw Environmental, Inc., Livonia MI
Phil Dula, Shaw Environmental, Inc., Overland Park, KS

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1.0 BACKGROUND

Shaw Environmental, Inc. (Shaw) was contracted by Deffenbaugh Industries, Inc. (Deffenbaugh) to complete a Human Health Risk Assessment (HHRA) for volatile organic compounds, 1,4-dioxane, and metals in groundwater at the former Quality Analytical Services (QAS) facility, located at 1633 Marsh Avenue in Blue Summit, MO. An oxbow of the Blue River lies approximately 400 feet west of the facility on the opposite (west) side of Interstate Highway 435 (Figure 1). The site was formerly a used-oil collection and recycling business operating from 1958 to 1996.

In 2000, impacted soil and concrete beneath the former tank farm was excavated and transported off-site for disposal. An interceptor trench was installed to extract light non-aqueous phase liquid (LNAPL) that was observed in monitoring wells along Marsh Avenue. A composite geosynthetic cover system was installed over the backfilled excavation and the area immediately surrounding it. Closure Certification was accepted by the Missouri Department of Natural Resources (MDNR) in January 2002, and the facility is now in compliance with the requirements of the approved Post-Closure Plan dated June 2002. Since the interceptor trench has not been successful in recovering all of the LNAPL from the impacted area, four pumping wells have been installed since June 2002 to extract groundwater near the leading edge of the impacted plume to intercept the impacted groundwater in the dissolved phase.

Groundwater occurs at a depth of approximately ten feet below ground surface. An oxbow of the Blue River, located west of Interstate Highway 435, is the closest downgradient surface water receptor (possible point of exposure) and is located between the QAS site and areas west of the river. Groundwater flow is to the west, toward the oxbow and the Blue River. The oxbow is approximately 100 feet wide (east to west). The Blue River flows to the north-northeast in the vicinity of the former QAS site.

2.0 INTRODUCTION

In support of the HHRA, surface water and sediment from the oxbow will be sampled to determine the concentration of volatile organic compounds (VOCs), 1,4-dioxane, and metals in the oxbow, which is the nearest downgradient surface water receptor. The VOC, 1,4-dioxane, and metals concentrations in the surface water and sediment will be incorporated into the HHRA. These data will also be used to assess ecological exposure for aquatic life, including invertebrates, fish, and aquatic plants impacted if site contaminants in groundwater discharge to the oxbow or to the Blue River. The potential for terrestrial animals drinking from, or foraging in, the oxbow or the Blue River areas to be exposed to site-related Constituents of Potential Concern (COPCs) will also be evaluated using these data.

Physical characteristics of the oxbow (depth, cross-sectional area, mean velocity) and sediment and surface water sampling will be conducted from a boat using a two-man crew. Prior to starting field activities, Shaw will prepare a site- and activity-specific Health and Safety Plan (HASP) covering surface water sampling, sediment sampling, depth and flow measurements, and boat operations. A Shaw geologist will serve as the site safety officer and ensure that the HASP is followed during field sampling operations.

3.0 PHYSICAL CHARACTERIZATION OF THE OXBOW

Depth and flow measurements will be taken at six transects, approximately 300 feet apart, across the oxbow as shown in Figure 2. Locations will be staked on both banks of the oxbow and the width of the oxbow at each transect will be measured A profile of the stream will be generated at each transect. The stream will be divided into evenly-spaced cells from bank to bank and total depths and stream velocities will be recorded at the center of each cell. The U.S. Geological Survey and Shaw SOP-T-GS-013 recommends using approximately 20 to 30 cells per transect. Each cell would be about 3 to 5 feet long for the oxbow, which is approximately 100 feet wide. The "east" bank will refer to the side of the oxbow nearest Interstate 435. Flow measurements will be made in accordance with Shaw SOP-T-GS-013, included in Appendix A. The stream velocity at 60% of the total depth of the stream (i.e., 0.6 x depth), or the average of the velocity at 20% and 80% of the total depth of the stream typically represent the mean velocity of the stream. The cross sectional area of the stream times the mean velocity equals the flow of the stream. The total flow is computed by summing the individual values of flow for each segment.

4.0 SEDIMENT AND SURFACE WATER SAMPLING

A total of ten sediment and ten surface water samples will be collected within the oxbow, one sediment and one surface water sample near the upgradient (east) end of each transect, and additional surface water samples in the middle and downgradient ends of selected transects. Groundwater flow is to the west-northwest toward the oxbow from the site. Four sample locations will be located in downgradient positions (OX-1, OX-2, OX-3, and OX-4) with two samples located in side-gradient (OX-5) and slightly upgradient (OX-6) positions to account for possible variation in groundwater flow direction. Four additional samples (OX-7, OX-8, OX-9, and OX-10) will be collected from the middle of the channel and the western end of selected transects. An upstream and downstream surface water sample will also be collected from the Blue River (Figure 2).

Sediment and surface water samples will be co-located. Sample locations will be measured and recorded in a field log book. Sediment samples will be collected in accordance with Shaw SOP-T-FS-124, and surface water samples will be collected in accordance with Shaw SOP-T-FS-113. Sediment sampling equipment will be decontaminated between samples in accordance with Shaw SOP-T-FS-014.

Shaw SOPs that will be used in this project include: SOP-T-FS-001 (Field Logbook), SOP-T-FS-003 (Chain-of-Custody – Paper), SOP-T-FS-006 (Sample Labels), SOP-T-FS-012 (Shipping/Packaging), SOP-T-FS-014 (Decontamination of Sampling Equipment), SOP-T-FS-113 (Surface Water Sampling), SOP-T-FS-124 (Ponar/Eckman), SOP-T-GS-013 (Standards for Conducting Stream Discharge Measurements). All SOPs are included in Appendix A.

Samples will be analyzed for volatile organic compounds using EPA Method 8260. Volatile organic compounds to be analyzed will include those listed in Table 1 of Deffenbaugh's Quality Assurance Project Plan for Post-Closure Activities at Industrial Services Corporation. 1,4-dioxane will be analyzed using EPA Method 1625M, and metals will be analyzed using EPA Method 200.7 or SW 846-6010B. Metals to be analyzed include arsenic, barium, cadmium, chromium, lead, manganese, mercury, nickel, selenium, and silver. This suite of analytes corresponds to the constituents of concern in groundwater samples collected by Deffenbaugh on May 26-27, 2004. The sampling and analysis plan is included as Table 1.

5.0 REPORTING

Once the chemical analytical data are received from the laboratory, these data will be supplied to Shaw risk assessors for incorporation into the HHRA. Shaw will validate the data collected during the field sampling activities as part of the HHRA.

TABLES

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TABLES

TABLE 1 – SAMPLING AND ANALYSIS PLAN

Medium	Locations	Samples	Duplicates	Total samples	Analyte	Method	Sample Preservation	Container	Holding time
Surface water	OX-1, OX-2, OX-3, OX-4, OX-5, OX-6, OX-7, OX-8, OX-9, OX-10 UPSTREAM, DOWNSTREAM, FIELD BLANK	13	1	14	Volatile organic compounds	EPA 8260B	Hydrochloric acid, pH<2	2-40 mL glass vials	14 days
					1,4-dioxane	EPA 1625M	Hydrochloric acid, pH<2	2-40 mL glass vials	14 days
					Total metals	EPA 200.7/6010B	Nitric acid, pH<2	500 mL glass	6 months
					Dissolved metals	EPA 200.7/6010B	Nitric acid, pH<2	500 mL glass	6 months
	Trip blank	1	--	1	Volatile organic compounds	EPA 8260B	Hydrochloric acid, pH<2	2-40 mL glass vials	14 days
					1,4-dioxane	EPA 1625M	Hydrochloric acid, pH<2	2-40 mL glass vials	14 days
Sediment	OX-1, OX-2, OX-3, OX-4, OX-5, OX-6, OX-7, OX-8, OX-9, OX-10	10	1	11	Volatile organic compounds	EPA 8260B	Hydrochloric acid, pH<2	2-40 mL glass vials	14 days
					1,4-dioxane	EPA 1625M	Hydrochloric acid, pH<2	2-40 mL glass vials	14 days
					Total metals	EPA 200.7/6010B	Nitric acid, pH<2	500 mL glass	6 months

FIGURES

FIGURES

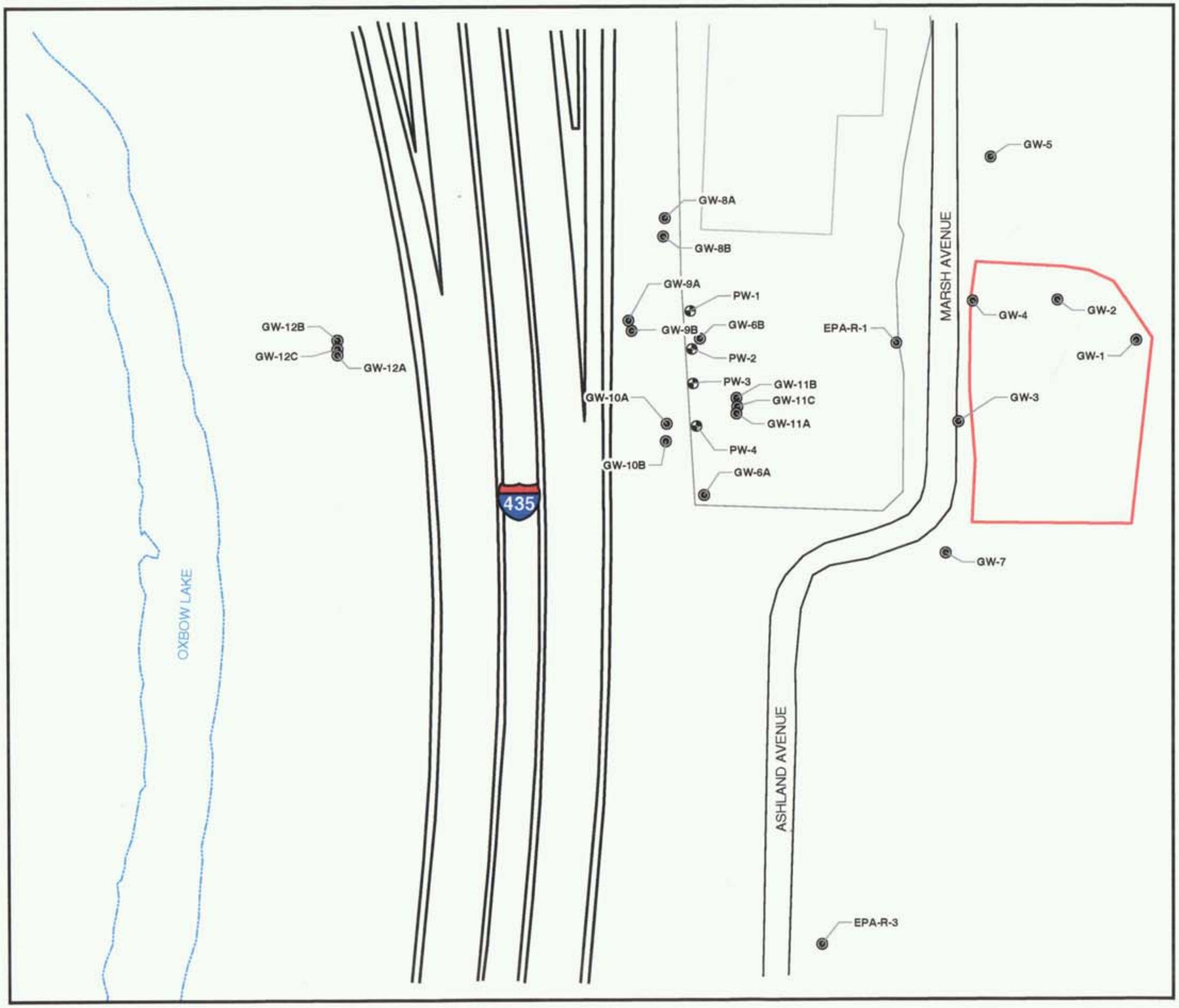

Figure 1

Quality Analytical Services Site Map

Shaw Environmental, Inc.

Figure 2

Quality Analytical Services Proposed Sample Location Map

Legend

● Proposed Sample Location

N

No Scale

Shaw™ Shaw Environmental, Inc.

APPENDIX A

APPENDIX A

Shaw Standard Operating Procedures

STANDARD OPERATING PROCEDURE

Subject: Field Logbook

1. PURPOSE

The objective of this Standard Operating Procedure (SOP) is to set criteria for content entry and form of field logbooks.

2. SCOPE

This procedure is applicable during all Shaw E & I site operations.

3. REFERENCES

- Nielsen Environmental Field School, 1997, *Field Notebook Guidelines*.

4. DEFINITIONS

4.1 **Site Logbook**—Logbook that is an index of all activities performed at the site. Specific entries are summaries of each day's activities. It is part of the project file.

4.2 **Field Logbook**—Logbooks used at field sites that contain detailed information regarding site activities including dates, times, personnel names, activities conducted, equipment used, weather conditions, etc. Field logbooks are used by a variety of different field personnel and are part of the project file.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

6.1 General

Each site or operation, as applicable, will have one current Site Logbook, which will serve as an index of all activities performed at the site. It is initiated at the start of the first on-site activity. Summary entries are made for every day that on-site activities take place. The details of all field activities shall be recorded in separate field logbooks. Multiple field logbooks may be used depending upon the number of different types of field personnel conducting activities at the site. These field logbooks and the site logbook shall be made part of the project files.

Information recorded in field logbooks includes observations, data, calculations, time, weather, and descriptions of the data collection activity, methods, instruments, and results. Additionally, the field logbook may contain descriptions of wastes, biota, geologic material, and site features including sketches, maps, or drawings as appropriate.

6.2 Equipment and Materials

- Site logbook
- Site-specific plans
- Hard-covered, waterproof field logbook(s)
- Indelible black ink pen
- Ruler or similar scale

6.3 Preparation

Site personnel responsible for maintaining field logbooks must be familiar with the SOPs for all tasks to be performed.

The field logbook will be assigned to an individual responsible for its care and maintenance.

Field logbooks are project files and should remain with project documentation when not in use.

Field logbooks shall be bound with lined, consecutively numbered pages. All pages must be numbered prior to initial use of the field logbook.

The following information shall be recorded inside the front cover of the field logbook:

- Person and organization to whom the book is assigned
- Phone number(s)
- Start date
- Project Name
- Shaw E & I Job Number
- Project Superintendent's Name
- Sequential Book Number (if applicable)

The first five pages of the field logbook shall be reserved for a table of contents. Mark the first page with the heading and enter the following:

TABLE OF CONTENTS

Date/Description	Page
(Start Date/Reserved for TOC)	1-5

The remaining pages of the Table of Contents will be designated as such with "TOC" written on the top center of each page.

6.4 Operation

The following requirements must be met when using a field logbook:

- Record work, observations, quantities of materials, calculations, drawings, and related information directly in the field logbook. If data-collection forms are specified by an activity-specific work plan, the information on the form need not be duplicated in the field logbook. However, any forms used to record site information must be referenced in the field logbook.
- Information should be factual and unbiased.
- Do not start a new page until the previous one is full or has been marked with a single diagonal line so that additional entries cannot be made. Use both sides of each page.
- Write in black, indelible ink. Do not write in pencil unless working in wet conditions.
- Do not erase or blot out any entry. Before an entry has been signed and dated, changes may be made; however, care must be taken not to obliterate what was written originally. Indicate any deletion by a single line through the material to be deleted. A change should be initiated and coded using one of the common data error codes shown in Attachment 1. All error codes should be circled.
- Do not remove any pages from the book.
- Do not use loose paper and copy into the field logbook later.
- Record sufficient information to completely document field activities.
- All entries should be neat and legible.

Specific requirements for field logbook entries include the following:

- Initial and date each page.
- Sign and date the final page of entries for each day.
- Initial and date all changes.
- Multiple authors must sign out the field logbook by inserting the following:

  Above notes authored by:

  ______________________________ (Sign name)

  ______________________________ (Print name)

  ______________________________ (Date)

- A new author must sign and print his/her name before additional entries are made.

- Draw a diagonal line through the remainder of the final page at the end of the day.
- Record the following information on a daily basis:

a) Date and time

b) Name of individual making entry

c) Description of activity being conducted including well, boring, sampling, location number as appropriate

d) Unusual site conditions

e) Weather conditions (i.e., temperature, cloud cover, precipitation, wind direction, and speed) and other pertinent data

f) People on site

g) Level of personal protection to be used

h) Arrival/departure of site visitors

i) Arrival/departure of equipment

j) Sample pickup (chain-of-custody form numbers, carrier, time)

k) Sampling activities/sample log sheet numbers

l) Start and completion of borehole/trench/monitoring well installation or sampling activity

m) Health and Safety issues

n) Instrumentation calibration details

Entries into the field logbook shall be preceded with the time of the observation. The time should be recorded frequently and at the point of events or measurements that are critical to the activity being logged. All measurements made and samples collected must be recorded unless they are documented by automatic methods (e.g., data logger) or on a separate form required by an operating procedure. In such cases, the field logbook must reference the automatic data record or form.

While sampling, record observations such as color and odor. Indicate the locations from which samples are being taken, sample identification numbers, the order of filling bottles, sample volumes, and parameters to be analyzed. If field duplicate samples are being collected, note the duplicate pair sample identification numbers. If samples are collected that will be used for matrix spike and/or matrix spike/matrix spike duplicate analysis, record that information in the field logbook.

A sketch of the station location may be warranted. All maps or sketches made in the field logbook should have descriptions of the features shown and a direction indicator. Maps and sketches should be oriented so that north is towards the top of the page.

Other events and observations that should be recorded include (but are not limited to) the following:

- Changes in weather that impact field activities
- Subcontractor activities
- Deviations from procedures outlined in any governing documents, including the reason for the deviation
- Problems, downtime, or delays
- Upgrade or downgrade of personal protective equipment

6.5 Post-Operation

To guard against loss of data due to damage or disappearance of field logbooks, copies of completed logbooks shall be securely stored by the project.

At the conclusion of each activity or phase of site work, the individual responsible for the field logbook will ensure that all entries have been appropriately signed and dated, and that corrections were made properly (single lines drawn through incorrect information, then initialed, coded, and dated). The completed field logbook shall be submitted to the project records file.

6.6 Restrictions/Limitations

Field logbooks constitute the official record of on-site technical work, investigations, and data collection activities. Their use, control, and ownership are restricted to activities pertaining to specific field operations carried out by Shaw personnel and their subcontractors. They are documents that may be used in court to indicate and defend dates, personnel, procedures, and techniques employed during site activities. Entries made in these notebooks should be factual, clear, precise, and as non-subjective as possible. Field logbooks, and entries within, are not to be utilized for personal use.

7. ATTACHMENTS

- Attachment 1—Common Data Error Codes.

8. FORMS

None.

ATTACHMENT 1
COMMON DATA ERROR CODES

COMMON DATA ERROR CODES

- RE Recording Error
- CE Calculation Error
- TE Transcription Error
- SE Spelling Error
- CL Changed for Clarity
- DC Original Sample Description Changed After Further Evaluation
- WO Write Over
- NI Not Initialed and Dated at Time of Entry
- OB Not Recorded at the Time of Initial Observation

All Error Codes should be circled

STANDARD OPERATING PROCEDURE

Subject: **Chain of Custody Documentation - Paper**

1. PURPOSE

The purpose of this procedure is to provide the requirements for completion of written Chain of Custody (COC) documentation and to provide a suggested Chain of Custody Form for project use.

2. SCOPE

This procedure is applicable to all Shaw E & I efforts where samples are transferred among parties, including to off-site testing facilities. Adherence to this procedure is not required whenever the same individual/team is performing the sampling and testing within the same workday, and transfer to the testing process is being documented by other means, e.g. sampling and then field-screening in a mobile laboratory.

3. REFERENCES

- U.S. Environmental Protection Agency, 1986, *Test Methods for Evaluating Solid Waste; Physical/Chemical Methods, SW-846*, Third Edition.
- U.S. Army Corps of Engineers, *Requirements for the Preparation of Sampling and Analysis Plans*, EM200-1-3.
- Shaw E & I, 2002, *Sampler's Training Course Handout.*

4. DEFINITIONS

- **Custody**—The legal term used to define the control and evidence traceability of an environmental sample. A sample is considered to be in an individual's custody when it is in actual physical possession of the person, is in view of the person, is locked in a container controlled by the person, or has been placed into a designated secure area by the person.
- **Chain of Custody Form**—A form used to document and track the custody and transfers of a sample from collection to analysis or placement in a designated secure area within the testing facility.
- **COC Continuation Page**—Additional page(s) that may be included with a Chain of Custody form. The continuation page(s) contain the information on additional samples contained within the *same* cooler/shipping container associated with the cooler/shipping container Chain of Custody form.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be directed to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw E & I employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

6.1 Documentation

All Chain of Custody documentation must be completed in indelible ink. All corrections must be performed using standard single-line cross-out methods, and the initials of the individual making the change must be included beside the corrected entry.

6.2 Continuation Pages

Continuation pages may be utilized for shipping containers/coolers with sufficient samples/sample containers that all of the lines of the Chain of Custody form are used before the documentation of the cooler/shipping container is complete. The number of pages in total must be filled out. *All samples entered onto a Continuation Page must be included in the same cooler/shipping container as those on the Chain of Custody form itself.*

6.3 Header Information

- Each Chain of Custody form must be assigned a unique Reference Document Number–use the Project/proposal number followed by a unique numeric sequence or current date (if only one cooler sent per day). Continuation Pages should contain the same Document Reference Number as the Chain of Custody form that they are associated with. The project team should maintain a log of Chain of Custody Reference Document Numbers.
- The page identifier and total page count section must be completed. Total pages include the Chain of Custody form and any attached Continuation Pages.
- Project number, name, and location information must be completed for all forms.
- If available, the laboratory Purchase Order Number should be included on the appropriate line.

- The name and phone number of the *Project Contact* should be included; the Project Contact should be a responsible individual that the laboratory may access to address analytical issues. This person is usually the analytical lead for the project

- The *Shipment Date* should be provided on the applicable lines.

- If shipping by carrier, the *Waybill/Airbill Number* must be included. Note: couriers will not sign custody documents. Therefore, inclusion of the waybill/airbill number on the Chain of Custody is the *only* means of documenting the transfer to the carrier.

- Laboratory Destination and Contact information should be provided.

- The Sampler(s) names should be provided on the appropriate line. This line should include all persons whose initials appear on any of the sample containers, to provide the laboratory a means of cross-referencing containers.

- The "Send Report To" information should be completed. If multiple reports/locations are needed, the information should be provided on a separate page included with the Chain of Custody documents.

6.4 Sample Information Section–Including on Continuation Page(s)

During actual sampling, each sample must be entered on the COC form at the time of collection in order to document possession. The sampler must not wait until sampling is completed before entering samples on the COC.

- Complete the *Sample ID Number* for each line. If there are multiple container types for a sample, use additional lines to indicate the needed information.

- Ensure that the *Sample Description* matches the description on the sample label–the laboratory will use this information for cross-referencing.

- Provide the *Collection Date* and *Time*. These must match those on the sample label and Field Logbook/Logsheets.

- Indicate whether the sample is a Grab or Composite sample.

- Indicate the *Matrix* of the sample. Use the Matrix Codes listed on the Chain of Custody form.

- Indicate the *Number of Containers* and the *Container Type*. If a sample has multiple container types, use multiple lines.

- Check the appropriate *Preservative* box for each line/container type.

- Write in and check the *Analyses Requested* boxes for each line/container type. The appropriate method number (e.g. EPA Method 8260C) must be written as well as the method name.

- Indicate the *Turn Around Time Requested* for each sample.

- Use the *Special Instructions* section to provide important information to the laboratory, e.g., samples that may require dilution or samples that will need to be composited by the laboratory. This section may also be used to inform the laboratory of additional information contained in attachments to the Chain of Custody package.

- Circle the appropriate *QC/Data Package Level* requested.

6.5 Custody Transfer Section

- The first *Relinquished By* space must be completed by the individual who will either transfer the samples or seal the shipping container.
- If the samples will be transferred to a courier, write the courier/carrier company in the *Received By* box and enter the Date and Time the shipping container was closed.
- All other transfers must be performed in person, and the Relinquisher must witness the signing by the Receiver.
- A copy of the Chain of Custody form and all associated Continuation Pages should be maintained in the project files.

7. ATTACHMENTS

None.

8. FORMS

- Shaw E & I Chain of Custody Form
- Shaw E & I COC Continuation Page

STANDARD OPERATING PROCEDURE

Subject: Sample Labeling

1. PURPOSE

The purpose of this procedure is to provide the requirements for completion and attachment of sample labels on environmental sample containers.

2. SCOPE

This procedure is applicable to all Shaw E & I projects where soil samples will be collected via hand auger methods.

3. REFERENCES

- U.S. Environmental Protection Agency, 1986, *Test Methods for Evaluating Solid Waste; Physical/Chemical Methods*, SW-846, Third Edition.
- U.S. Army Corps of Engineers, *Requirements for the Preparation of Sampling and Analysis Plans*, EM200-1-3
- Shaw E & I, 2002, Sampler's Training Course Handout.

4. DEFINITIONS

- **Sample Label**—Any writing surface with an adhesive backing that can be used to document sample identification information. The sample label is attached to the sample container as a means of identification and, in some commercially available or laboratory-supplied containers, may be pre-attached. All Shaw E & I strategic alliance laboratories provide sample labels or pre-labeled containers in their sample container supply kits.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw E & I employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw E & I employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

- All sample labels must be completed in indelible ink. All corrections must be performed using standard single-line cross-out methods, and the initials of the individual making the change must be included beside the corrected entry.
- Sample labels should be completed and attached as samples are collected. Do not wait until final packaging to attach and/or complete the sample labels.
- Sample labels must be attached to the non-sealing portion of the container. Do not place labels on or across sample container caps.
- If the laboratory has provided pre-labeled containers, make sure to fill one for each parameter set needed. Laboratory pre-labeled containers are often bar-coded and it is important to provide a complete container set for each sample.
- The following information must be recorded on the Sample Label:
  - Sample Identification Number
  - Date and Time collected
  - Initials of person(s) responsible for collection
- If a space is provided, the *Analysis Requested* should also be added.
- If a *Description* is provided, remember it must match that on the Chain of Custody form for cross-referencing purposes.
- Cover the completed and attached label with clear plastic tape to prevent bleeding of the ink if it becomes wetted.

7. ATTACHMENTS

None.

8. FORMS

None.

STANDARD OPERATING PROCEDURE

Subject: Shipping and Packaging of Non Hazardous Samples

1. PURPOSE

The purpose of this procedure is to provide general instructions in the packaging and shipping of non-hazardous samples. The primary use of this procedure is for the transportation of samples collected on site to be sent off site for physical, chemical, and/or radiological analysis.

2. SCOPE

This procedure applies to the shipping and packing of all non-hazardous samples. Non-hazardous samples are those that do not meet any hazard class definitions found in 49 CFR 107-178, including materials designated as Class 9 materials and materials that represent Reportable Quantities (hazardous substances).

In general most soil, air, and aqueous samples do not meet any of DOT's hazardous materials definitions. However, samples for which screening has shown a potential hazard sufficient to meet a DOT definition or that are derived from a source known or suspected to meet a DOT definition must be packaged and shipped in accordance with the applicable DOT and/or IATA requirements. Refer to Shaw E & I SOP T-FS-013.

3. REFERENCES

- U.S. Army Corps of Engineers, 2001, *Requirements for the Preparation of Sampling and Analysis Plans*, EM200-1-3, Washington, D.C.
- U.S. Department of Transportation Regulations, 49 CFR Parts 108-178
- International Air Transport Association (IATA), *Dangerous Goods Regulations*, current edition.

4. DEFINITIONS

- **Cooler/Shipping Container**—Any hard-sided insulated container meeting DOT's or IATA's general packaging requirements.
- **Bubble Wrap**—Plastic sheeting with entrained air bubbles for protective packaging purposes.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

6.1 Packaging

- Use tape and seal off the cooler drain on the inside and outside to prevent leakage.
- Place packing material on the bottom on the shipping container (cooler) to provide a soft impact surface.
- Place a 55-gallon or equivalent plastic bag into the cooler (to minimize possibility of leakage during transit).
- Starting with the largest glass containers, wrap each container with sufficient bubble wrap to ensure the best chance to prevent breakage of the container.
- Pack the largest glass containers in bottom of the cooler, placing packing material between each of the containers to avoid breakage from bumping.
- Double-bag the ice (chips or cubes) in gallon or quart freezer zip-lock plastic bags and wedge the ice bags between the sample bottles.
- Add bagged ice across the top of the samples.
- When sufficiently full, seal the inner protective plastic bag, and place additional packing material on top of the bag to minimize shifting of containers during shipment.
- Tape a gallon zip-lock bag to the inside of the cooler lid, place the completed chain of custody document inside, and seal it shut.
- Tape the shipping container (cooler) shut using packing tape, duct tape, or other tear-resistant adhesive strips. Taping should be performed to ensure the lid cannot open during transport.
- Place a custody seal on two separate portions of the cooler, to provide evidence that the lid has not been opened prior to receipt by the intended recipient.

6.2 Labeling

- A "This Side Up" arrow must be adhered to all sides of the cooler.
- The name and address of the receiver and the shipper must be on the top of the cooler.
- The airbill must be attached to the top of the cooler.

6.3 Shipping Documentation

- A Cooler Shipment Checklist (Attachment 1) should be completed and kept in the project file.

7. ATTACHMENTS

- **Attachment 1**—Shaw E & I Cooler Shipment Checklist

8. FORMS

None.

SAMPLE SHIPMENT CHECKLIST

Shaw™
Shaw E & I, Inc.

Project Name ____________ Project Number ____________
Address ____________ Date ________ Time ________
City, State, Zip ____________ Fax No. ____________
Site Contact No. ____________

SAMPLE CHECKLIST	YES	NO	COMMENTS
SAMPLE LIDS ARE TIGHT AND CUSTODY SEALS IN PLACE?	☐	☐	
ARE ALL SAMPLE NUMBERS, DATES, TIMES AND OTHER LABEL INFORMATION LEGIBLE AND COMPLETE?	☐	☐	
HAVE ALL SAMPLE NUMBERS, DATES, TIMES AND OTHER SAMPLING DATA BEEN LOGGED INTO THE SAMPLE LOG BOOK?	☐	☐	
DO SAMPLE NUMBERS AND SAMPLE DESCRIPTIONS ON THE LABELS MATCH THOSE ON THE COC?	☐	☐	
HAVE THE SAMPLES BEEN PROPERLY PRESERVED?	☐	☐	
HAVE THE CHAIN OF CUSTODIES BEEN FILLED OUT COMPLETELY AND CORRECTLY?	☐	☐	
DOES THE ANALYTICAL SPECIFIED ON THE COC MATCH THE ANALYTICAL SPECIFIED IN THE SCOPE OF WORK?	☐	☐	
HAVE THE COC'S BEEN PROPERLY SIGNED IN THE TRANSFER SECTION?	☐	☐	

PACKAGING CHECKLIST	YES	NO	COMMENTS
HAS EACH SAMPLE BEEN PLACED INTO AN INDIVIDUAL PLASTIC BAG?	☐	☐	
HAS THE DRAIN PLUG OF THE COOLER BEEN TAPED CLOSED WITH WATER PROFF TAPE FROM THE INSIDE?	☐	☐	
HAVE ALL THE SAMPLES BEEN PLACED INTO THE COOLER IN AN UPRIGHT POSITION?	☐	☐	
IS THERE ADEQUATE SPACING OF SAMPLES SO THAT THEY WILL NOT TOUCH DURING SHIPMENT?	☐	☐	
HAVE AN ADEQUATE NUMBER OF BLUE ICE PACKS OR WATER ICE BEEN PLACED AROUND AND ON TOP OF THE SAMPLE?	☐	☐	
HAS FRESH BLUE ICE OR WATER ICE BEEN ADDED TO THE COOLER THE DAY OF THE SHIPMENT?	☐	☐	
HAS THE COOLER BEEN FILLED WITH ADDITIONAL CUSHIONING MATERIAL?	☐	☐	
HAS THE COC BEEN PLACE IN A ZIPLOCK BAG AND TAPED TO THE INSIDE OF THE LID OF THE COOLER?	☐	☐	
HAVE CUSTODY SEALS BEEN PLACED ONTO THE LID?	☐	☐	
HAS THE COOLER BEEN LABELED "THIS SIDE UP"?	☐	☐	
IF REQUIRED, HAS THE COOLER BEEN LABELED WITH THE DOT PROPER SHIPPING NAME, UN NUMBER AND LABEL?	☐	☐	
HAS THE LABORATORY PERFORMING THE ANALYSES BEEN NOTIFIED OF THE SHIPMENT OF SAMPLES?	☐	☐	

PROBLEMS/RESOLUTIONS: ____________

PREPARED BY: ____________ SIGNATURE ____________

STANDARD OPERATING PROCEDURE

Subject: Decontamination of Contact Sampling Equipment

1. PURPOSE

This procedure defines the Shaw E & I standard that must be implemented for decontamination of contact sampling equipment. Contact sampling equipment is equipment that comes in direct contact with the sample or portion of sample that will undergo chemical analyses or physical testing. This SOP is intended to provide minimum guidelines and general procedures for decontaminating contact sampling equipment used during field sampling activities. The benefits of its use include the following:

- Minimizing the spread of contaminants within a study area and from site to site
- Reducing the potential for worker exposure by means of contact with contaminated sampling equipment
- Improved data quality and reliability

2. SCOPE

This procedure applies to all instances where non-disposable direct contact sampling equipment is utilized for sample collection. This procedure is not intended to address decontamination of peristaltic or other sampling pumps and tubing. The steps outlined in this procedure must be executed between each distinct sample data point.

3. REFERENCES

- U.S. Environmental Protection Agency, Region 4, 2001, *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*, 980 College Station Road, Athens, Georgia. November.
- US Army Corp of Engineers, Washington, D.C., 2001, Requirements for the Preparation of Sampling and Analysis Plans (EM-200-1-3), February.

4. DEFINITIONS

- **Soap**—A standard brand of phosphate-free laboratory detergent, such as Liquinox®.
- **Organic Desorbing Agent**—A solvent used for removing organic compounds. The specific solvent would depend upon the type of organic compound to be removed. See Attachment 1 for recommendations.
- **Inorganic Desorbing Agent**—An acid solution for use in removing trace metal compounds. The specific acid solution would depend upon the type of inorganic compound to be removed. See Attachment 1 for recommendations.
- **Tap water**—Water obtained from any municipal water treatment system. An untreated potable water supply can be used as a substitute for tap water if the water does not contain the constituents of concern.

- **Analyte-free water (deionized water)**—Water that has been treated by passing through a standard deionizing resin column, and for organics either distillation or activated carbon units. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds, and/or no detectable organic compounds (i.e., at or above analytical detection limits). Analyte-free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.

  Other solvents may be substituted for a particular purpose if required. For example, removal of concentrated waste materials may require the use of either pesticide-grade hexane or petroleum ether. After the waste material is removed, the equipment must be subjected to the standard cleaning procedure. Because these solvents are not miscible with water, the equipment must be completely dry prior to use.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

6.1 Health and Safety

Minimum Health and Safety Procedures should be implemented based on the site-specific decontamination protocol that is designed. Health and Safety procedures should take into consideration the potential use of either dangerous solvents or corrosive liquids.

6.2 Implementation

A decontamination area should be established. A separate tub needs to be available for each of the first four steps. Each type of water and soap solution can be placed in hand-held sprayers made of an inert material. The analyte-free water needs to be placed in a container that will be free of any compounds of concern. Special containers will be needed if solvents or acid solutions are used. For example, an acid solution cannot be placed in a sprayer that has any metal parts that will come in contact with the acid solution.

The minimum steps for decontamination are as follows:

1. Remove particulate matter and other surface debris using appropriate tools such as a brush or hand-held sprayer filled with tap water.

2. Scrub the surfaces of the contact sampling equipment using tap water and soap solution and a second brush made of inert material.
3. Rinse contact sampling equipment thoroughly with tap water.
4. Rinse contact sampling equipment thoroughly with analyte-free water (not necessary if sampling for disposal profiling purposes).
5. Place contact sampling equipment on a clean surface appropriate for the compounds of concern and allow to air dry.

It is Shaw E & I policy to containerize all decontamination fluids. This policy will be followed unless an the client specifically directs an alternate procedure in writing.

The use of solvents and/or acid solutions will be dependent on the site-specific conditions. A site with a high probability of high concentrations of compounds or with waste material present will require additional decontamination procedures. Attachment 1 provides some guidance for additional decontamination procedures.

7. ATTACHMENTS

- **Attachment 1**—Recommended Decontamination Procedures.

8. FORMS

None.

ATTACHMENT 1
RECOMMENDED DECONTAMINATION PROCEDURES

Compound	Detergent Wash	Tap Water	Inorganic Desorbing Agent	Tap Water	Organic Desorbing Agent[1]	Deionized Water	Air Dry
Organics							
Volatile Organic Compounds	✓	✓			Methanol Purge & Trap grade	✓	✓
Base Neutrals/Acid Extractables/PCBs/Pesticides	✓	✓			Hexane	✓	✓
Organic Bases[2]	✓	✓	1% nitric acid	✓	Isopropyl Alcohol	✓	✓
Organic Acids[3]	✓	✓	1% nitric acid		Isopropyl Alcohol	✓	✓
Inorganics							
Trace Metals and Radio Isotopes	✓	✓	10% Nitric acid -Trace metals grade	✓		✓	✓
Cations/Anions	✓	✓				✓	✓
Acidic Compounds	✓	✓				✓	✓
Basic Compounds (caustic)	✓	✓	1% nitric acid	✓		✓	✓

1 – All organic solvents must be Pesticide Grade or better. The selection of appropriate solvent rinses should first consider if a *known or suspected* contaminant requires removal from sampling equipment. Secondly, identify whether the subsequent analytical protocol would be impacted by the proposed solvent or an impurity thereof (e.g., residual acetone present in isopropyl alcohol would be measured with certain volatile organics analysis).

2 - Organic bases include amines, hydrazines.

3 - Organic acids include phenols, thiols, nitro and sulfonic compounds.

Adapted from: Appendix E, Requirements for the Preparation of Sampling and Analysis Plans (EM-200-1-3), February 2001. US Army Corp of Engineers, Washington, D.C.

STANDARD OPERATING PROCEDURE

Subject: **Surface Water Sampling**

1. PURPOSE

The purpose of this document is to provide methods, procedures, and guidance for sampling of surface waters or liquids in lakes, streams, pits, sumps, lagoons, and similar reservoirs for environmental analysis.

2. SCOPE

This procedure is applicable to all Shaw E & I projects where surface water sampling will be performed and where no project/program plan or procedure is in place to direct those activities.

The procedure presents two methods of sampling: direct immersion of sampling containers and use of a pond sampler.

3. REFERENCES

- U.S. Army Corps of Engineers, 2001, *Requirements for the Preparation of Sampling and Analysis Plans*, EM 200-1-3, Appendix C, Washington, D.C.
- U.S. Environmental Protection Agency, 1994, *Surface Water Sampling,* EPA/ERT SOP 2013.

4. DEFINITIONS

- **Pond Sampler**—A type of liquid sampling device consisting of an adjustable aluminum or fiberglass pole with an adjustable clamp to hold a container on one end. The pole allows for grab samples to be obtained at distances as far as 10 to 12 feet from the edge of the source without the need to contact the medium.
- **Grab Sample**—A single sample representative of a specific location at a given point in time.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be directed to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

Safety Note: Surface water sampling can sometimes require the use of boats or access into or across bodies of water. Observe all boating safety considerations in the HASP including donning of proper life jackets. If sampling from a bank, do not overreach; use a Pond Sampler whenever possible and do not attempt to remove the container from the clamp while still in contact or close proximity to the water body. Do not wade into a water body unless the depth is well known, currents are flowing at a safe speed, appropriate personnel have determined it is safe, and a spotter is available.

6.1 Direct Immersion

The following procedure shall be used for direct immersion sampling:

- Don a pair of clean gloves.
- Obtain the required sample container(s)
- If entering the water body, always do so with as little bottom disturbance as possible and wait for the water around the planned sampling area to return to its undisturbed state (clarity) before sampling.
- Collect each liquid sample by slowly submerging the sample container with minimal surface disturbance. If sampling in a stream or current, make sure the open end of the sample container is pointed upstream.
- Retrieve the container from the liquid with minimal disturbance; cap and wipe the outside of the container with a towel or cloth.
- If collecting samples for VOC analysis, make sure that the VOA vial is slightly overfilled before capping and check for bubbles or trapped air by inverting. If the sample integrity is compromised, discard the sample and repeat the collection process.
- Complete all required documentation, and place the sample containers into a cooler or other specified container.

6.2 Pond Sampler

The following procedure shall be used for sampling with a pond sampler:

- Don a pair of clean gloves.
- Place plastic sheeting around the area where the sampler will be emptied.
- Assemble the pond sampler and secure the sample container or collection jar/bottle/beaker in the adjustable clamp.
- If entering the water body, always do so with as little bottom disturbance as possible and wait for the water around the planned sampling area to return to its undisturbed state (clarity) before sampling.
- Collect each liquid sample by extending the container end outward and slowly submerging the sample container while holding the Pond Sampler handle with minimal surface disturbance. If sampling in a stream or current, make sure the open end is pointed upstream.

- Retrieve the container from the liquid with minimal disturbance, retract any extensions, transport the sample while still on the clamp to the emptying area, and remove it from the clamp.
- Alternatively, if sampling with a partner, the partner can remove the collection container from the clamp and carry it to the transfer area
- If the container is the one to be used for the sample, remove it from the clamp, cap, and label.
- If the sampler was used to collect a fill container, remove the lid(s) from the required sample containers and slowly transfer the sample into the appropriate containers; cap and label each one.
- Collect samples for VOC analysis, making sure that the VOA vial is slightly overfilled before capping, and check for bubbles or trapped air by inverting. If the sample integrity is compromised, discard the sample and repeat the vial filling process.
- Complete all required documentation, and place the samples into a cooler or other specified container.
- After each use (i.e. between sample locations), the pond sampler must be disassembled and decontaminated, especially at the clamp area.

Sample jars or beakers are attached to the pole using the clamps for collecting the sample. With a pond sampler device, sample jars can be attached directly to the sample pole and the sample directly filled into the sample jar or a sampling beaker can be attached to the pole and the collected sample would then be transferred to an appropriate sample jar. If sample jars are filled directly, they should be wiped clean prior to being placed in the cooler for shipment. If sampling beakers are used, they can be disposed of or decontaminated prior to reuse

7. ATTACHMENTS

None.

8. FORMS

None.

STANDARD OPERATING PROCEDURE

Subject: Sediment Sampling using Ponar/Ekman Type Systems

1. PURPOSE

The purpose of this document is to provide the methods and procedures for sampling of sediments using clamshell-type sampling devices such as the Ponar and Ekman systems. These sampling systems can be utilized to collect non-core sediment samples. If core samples are desired, alternative methods should be used.

2. SCOPE

This procedure is applicable to all Shaw E & I projects where non-core sediment samples will be collected via clamshell sampling device methods.

3. REFERENCES

- U.S. Army Corps of Engineers, *Requirements for the Preparation of Sampling and Analysis Plans,* Appendix C, Section C.6, EM200-1-3, Washington, D.C.
- Wildlife Supply Company (WILDCO) web-site at http://www.wildco.com.

4. DEFINITIONS

- **Clamshell Device**—A sampling device consisting of spring-loaded jaws that activate either by contact with the bottom or by other means and entrap the collected materials for retrieval. These devices can be operated via hand line or with a winch for deep-water operations.
- **Ekman Sampler**—A type of clamshell device designed for use in soft bottoms. The Ekman sampler rests on the bottom and uses a messenger system to activate the closure spring and scoops up the material caught between the jaws upon closure.
- **Ponar Sampler**—A type of clamshell device designed for hard and gravelly bottoms. Unlike the Ekman, a Ponar sampler self-activates its closure mechanism after it penetrates into the bottom material. Ponar samplers are heavy (45 lbs.) and require a winch to operate.
- **Messenger**—A metal, usually lead, weight with a hole through its core that is used to activate the spring closure on clamshell devices. The messenger is dropped onto the closure activation mechanism by sliding it down a line. It activates the closure by the force of its weight upon impact.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw E & I employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw E & I employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

Safety Notes: These sampling devices are spring activated; they close with great force and are capable of causing injury. Care should be used when opening and securing these devices in the "ready" position. Do not handle by the trip line and always transport in the closed position. Always use proper life-saving equipment when sampling from a boat or barge. Consult the project Health and Safety Plan for requirements.

6.1 Equipment

The following equipment should be used when sampling sediments using clamshell-type sampling devices:

- Decontaminated commercial clamshell sampling device, stainless steel construction for trace environmental sampling
- Rope or line with graduations, on winch if required
- Weighted line with graduations to determine depth to bottom, or depth finder if available
- Separate line for messenger if applicable
- Carpenter's chalk
- Plastic sheeting, to keep emptying area clean
- Plastic or metal shallow pan, to empty sampler into–decontaminated or dedicated
- Stainless steel spoons or scoops–decontaminated or dedicated
- Decontaminated or dedicated stainless steel bowl

6.2 Sampling

The following procedure should be used when sampling sediments using clamshell-type sampling devices:

1. Don a pair of clean gloves.
2. Place plastic sheeting around the area where the sampler will be emptied to keep sampled material in place.
3. Determine the depth to the bottom using the weighted line or depth finder and then mark the sample's line at the distance representative of approximately 1m from the bottom with chalk.

4. Attach the line to the sampler and, if applicable, the messenger line. If the messenger has a separate line, make sure it is at least as long as the tag line. *Do not place the messenger on the line at this time.*
5. Carefully open and lock the sampler. From this point on, handle it only by the tag line and take care not to strike it on the release mechanism.
6. Attach the free end of the tag line to a secure holding place to keep from losing the sampler.
7. Being careful not to contact the sampler, slowly lower it into the water until the 1m-to-bottom mark is reached. Make sure that the rope/line does not become entangled.
8. Slow the descent further and continue until the bottom is contacted. Contact with the bottom will be evidenced when the descent stops and slack appears in the line.
9. If sampling with a Ponar, the slack in the line should have activated the closure mechanism. If using a messenger-type system, thread the messenger onto the tag or trip line and allow it to fall and trip the device.
10. Free the device from the bottom by pulling straight up on the tag line, and slowly raise it until it is about 1 to 2 feet from the surface while being careful not to allow the rope/line coils to entangle on anything.
11. Prepare and clear the sample receiving area, and then slowly raise the sampler out of the water.
12. Allow clear water to drain, and swing the sampler onto the pan in the receiving area once the clear liquids are drained. Do not allow the fine particles to exit the sampler also.
13. If a messenger was used, remove it from the line to keep from accidentally tripping the device when retrieving the sample. Carefully open and lock the sampler and allow the sample to fill the pan. Put the sampler aside for cleaning and decontamination.
14. If collecting samples for VOC analysis, these samples should be taken first from the material in the pan using corer or syringe-type methods.
15. The remainder of the sample material should be mixed in the pan and placed into labeled sample containers or other plan-required receptacles using the spoon or scoop.
16. Complete all required documentation, and place the sample into a cooler or other plan-specified container.
17. Decontaminate the sampler on the inside and outside while open and closed to remove all particles. Dry and return the sampler to its "closed" position when completed.

7. ATTACHMENTS

None.

8. FORMS

None.

SOP T-GS-013

Standards for Conducting Stream Discharge Measurements

Prepared By: ______________________ Date: ______________
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Senior Hydrogeologist

Authorized By: ______________________ Date: ______________
John E. Sciacca, R.G.
Geosciences Discipline Lead

STANDARD OPERATING PROCEDURE

Subject: Standards for Conducting Stream Discharge Measurements

1. PURPOSE

This procedure provides the standard practice for conducting direct stream discharge measurements. The procedure includes the minimum required steps and quality checks that employees and subcontractors are to follow when performing the subject task.

This procedure may also contain guidance for recommended or suggested practice that is based upon collective professional experience. Recommended practice goes beyond the minimum requirements of the procedure, and should be implemented when appropriate.

2. SCOPE

Geosciences Standard Operating Procedure (SOP) T-GS-013 describes standards for conducting open-channel, direct discharge measurements from small channels, streams, and creeks (generally during mid to low or base flow conditions, and for performing seepage or gain-loss measurements), springs, seeps, ditches, sewers, pond inlets and outlets, underground mine openings (e.g., adits and tunnels), and similar surface water discharges (collectively called streams for the purpose of description in this SOP). The SOP addresses how such work will be conducted and documented for projects executed by Shaw Environmental & Infrastructure, Inc., (Shaw E & I). The procedure was developed to address the collection of stream flow data on a periodic basis without the use of permanently installed gaging stations, weirs, or flumes.

Federal, state, and local government agencies should be contacted for stream flow data on larger streams and rivers, flood flow data, and long term records. Government agencies, such as the U.S. Geological Survey, U.S. Army Corps of Engineers, U.S. National Oceanic and Atmospheric Administration, and U.S. Forest Service, maintain long-term stream gages and historical databases.

The SOP addresses technical requirements and required documentation. Responsibilities of individuals performing the work are also detailed. Additional, project-specific requirements for conducting stream discharge measurements may be developed, as necessary, to supplement this procedure and to address project-specific conditions or objectives.

3. REFERENCES (STANDARD INDUSTRY PRACTICES)

Performing stream discharge measurements should follow accepted industry practices. These industry practices are presented in the latest version of various ASTM Standards and the references provided below:

ASTM D 1941 – 91	Standard Test Method for Open Channel Flow Measurement of Water with the Parshall Flume (Reapproved 2001)
ASTM D 3858 – 95	Standard Test Method for Open-Channel Flow Measurement of Water by Velocity-Area Method (Reapproved 1999)
ASTM D 4409 – 95	Standard Test Method for Velocity Measurements of Water in Open Channels with Rotating Element Current Meters (Reapproved 1999)
ASTM D 5089 – 95	Standard Test Method for Velocity Measurements of Water in Open Channels with Electromagnetic Current Meters (Reapproved 1999)

ASTM D 5242 – 92	Standard Test Method for Open-Channel Flow Measurement of Water with Thin-Plate Weirs
ASTM D 5640 – 95	Standard Guide for Selection of Weirs and Flumes for Open-Channel Flow Measurement for Water (Reapproved 1999)
ASTM D 5906 – 02	Standard Guide for Measuring Horizontal Positioning During Measurements of Surface Water Depths

Buchanan, T.J., and Somers, W. P., "Stage Measurement at Gaging Stations," *Techniques of Water Resources Investigations of the U.S. Geological Survey*, Book 3, Chapter A-7, U.S. Government Printing Office, 1968.

Buchanan, T.J., and Somers, W. P., "Discharge Measurements at Gaging Stations," *Techniques of Water Resources Investigations of the U.S. Geological Survey*, Book 3, Chapter A-8, U.S. Government Printing Office, 1969.

Carter, R. W., and Davidian, Jr., "General Procedures for Gaging Streams," *Techniques of Water Resources Investigations of the U.S. Geological Survey*, Book 3, Chapter A-6, U.S. Government Printing Office, 1969

Kilpatrick, F. A., and Schneider, V. R., "Use of Flumes in Measuring Discharge," *Techniques of Water Resources Investigations of the U.S. Geological Survey*, Book 3, Chapter A-14, U.S. Government Printing Office, 1983.

Smoot, G. E., and Novak, C. E., "Calibration and Maintenance of Vertical Axis Type Current Meters," U.S. Geological Survey, *Techniques of Water Resources Investigations*, Book 8, Chapter B-2, 1968.

U.S. Bureau of Reclamation, "*Water Measurement Manual,*" Third Edition Revised Reprint, U.S. Government Printing Office, 1997.

4. DEFINITIONS

The following definitions are applicable to conducting stream discharge measurements and this SOP.

- **Base Flow**—The part of stream discharge from groundwater seepage.
- **Current Meters**—Mechanical and electromagnetic instruments used to measure the velocity of flowing water at a point.
- **Discharge**—A rate of surface water flow defined as the volume of water that passes a particular reference channel cross section in a unit of time. Generally, reported in cubic feet per second (cfs).
- **Flumes (Parshall or Trapezoidal)**—A prefabricated, specially shaped open-channel flow section, of a specified geometry (venturi) for which empirical relations have been established. The flumes are fitted into a channel so that flow can be determined from a single depth measurement.
- **Head**—The height or elevation of the water surface above a specified point.
- **Hydrographer**—A person performing stream flow measurements and calculations.
- **Low Flow Measurements**—Stream measurements made during base flow conditions to determine the groundwater discharge.
- **Nappe**—The sheet of water leaving the weir.

- **Normal Stream Flow**—In this SOP, refers to average stream flows for the period, not flood flows.
- **Open-Channel Flow**—Free surface flow, or all cases of flow in which the liquid surface is open to the atmosphere.
- **Price-Type Current Meter**—Generic name for specific mechanical vertical axis current meters with a rotating element consisting of six cones secured to a central, rotating shaft.
- **Rod Floats**—Wooden rods weighted at one end, so that they float upright in a stream; used to measure flow velocity.
- **Seepage Measurements**—Also known as stream gain-loss measurements. Discharge measurements performed to determine where groundwater is discharging to a stream (gaining reach) and where the stream is recharging groundwater (losing reach).
- **Spin Test**—A test performed to check the bearings of a vertical axis current meter. Acceptable spin duration is supplied by the manufacturer.
- **Stream**—For the purpose of this SOP; any open-channel surface water flow that can be measured: by inserting prefabricated flow structures; by using over flow structures; by diverting into pipes and calibrated containers; by wading; or, from overhead structures (bridges). This includes creeks, springs, seeps, ditches, sewers, pond inlets and outlets, mine adits and tunnels, and similar water discharges.
- **Stream Cross Section**—The depth and width of a stream section perpendicular to flow, where discharge is to be computed.
- **Stream Cross-Sectional Area**—The area of the stream channel below the water surface, where velocity is measured and discharge computed measured.
- **Stream Gaging**—The act of measuring stream discharge.
- **Stream Stage**—The height of a water surface above a datum plane.
- **Surface Floats**—Almost anything that floats on the water surface (such as wooden disks, partly filled bottles, oranges) used to measure flow velocity.
- **Tagline**—A measuring line having markings at fixed intervals along its length to indicate distance. Usually a taut cable or line anchored firmly at opposite banks across a stream cross section, used during stream velocity measurements.
- **Volumetric Measurements**—The measurement of small flows by determining the time to fill, or partially fill, a container of known volume.
- **Wading Rod**—A round, graduated tool for measuring the depth of a water column in tenths of a foot. The rod is also used to hold the current meter at the appropriate depth in the stream to measure velocities. The rod can be a single support (where the meter is secured at a predetermined depth by a set-screw for the velocity measurement) or a two-piece top-setting rod, (where the meter is secured on a sliding rod that is moved up and down the main rod and secured at the handle). The top-setting rod is more convenient for performing the velocity measurements, since it is designed to set the meter at the appropriate water depth after the total depth of the stream is measured.
- **Weirs**—An overflow structure of specified geometry, built across an open channel to measure the rate of flow of water. The volumetric flow rate is a unique function of a single measured depth above a weir crest

5. RESPONSIBILITIES

5.1. Procedure Responsibility

The Geosciences Discipline Lead is responsible for the development, maintenance, and revision of this procedure. Any questions, comments, or suggestions regarding this technical SOP should be sent to the Geosciences Discipline Lead. The Geosciences Discipline Lead's location and associated contact information can be found on the Insider.

5.2. Project Responsibility

Employees planning or conducting stream discharge measurements, or any portion thereof, are responsible for meeting the requirements of this procedure. Employees conducting technical review of company projects, where stream discharge measurements are performed, are also responsible for following appropriate portions of this SOP.

For those projects where stream discharge measurements are conducted, the Project Manager, or designee, is responsible for ensuring that these activities are implemented in accordance with this and other appropriate procedures. Project participants are responsible for recording information in sufficient detail to provide objective documentation (i.e., checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURES (TECHNICAL REQUIREMENTS AND STANDARDS)

This text describes the procedures and techniques for making discharge measurements by using methods such as inserting prefabricated flow structures or over flow structures into the stream, creating diversion into pipes and calibrated containers, wading, or from overhead structures (bridges) spanning the stream. The methods for recording and computing discharge are also detailed.

A stream discharge measurement may be defined as the measurement of a volume of flowing fluid moving across a fixed plane during a given unit of time. Proper stream discharge measurements and calculations are necessary to insure the accuracy and representativeness of the results. The details within this SOP should be used in conjunction with the project-specific work plans. The project work plans will generally provide the following information:

- Stream discharge measurement objectives
- Type(s) of stream discharge methods to be employed
- Locations for performing the discharge measurements
- Health and safety requirements
- Quality Assurance/Quality Control (QA/QC) and records retention requirements

Stream discharge measurements may be performed by a number of acceptable techniques depending on stream flow rate, channel geometry and hydraulic conditions. The most common techniques used to measure stream flow include:

- Velocity-area using current meters
- Weir plates
- Flumes (Parshall or trapezoidal)
- Volumetric measurements
- Surface floats

These techniques and required documentation are described below. Other methods may be employed if they are more suitable to project conditions and meet the general requirements of this SOP. The listed ASTM Standards and reverences should be reviewed for guidance in selecting the proper stream discharge measurement methods.

6.1. Methodology and General Procedures

The following text discusses basic measurement methods, considerations and procedures.

6.1.1. Velocity-Area Method Using Current Meters

The most common method for measuring the discharge of a stream is the velocity-area method. The method requires the physical measurement of both the area and velocity of the flowing water. The formula used to compute the discharge is $Q = AV$, where Q is the discharge in cubic feet per second (cfs), A is the stream cross sectional area in square feet, and V is the average velocity across the section in feet per second. Measurements are generally performed by wading, or from an overhead structure. Water depth and distance across the stream are determined by use of a wading rod and tag line. Velocity measurements are determined by use of a current meter. The type of meter selected will be dependent on the channel depth range of velocities encountered. The most common current meters in use are Price AA and Pigmy (mini).

Since stream velocity varies in the vertical direction, measurements are made at a depth generally representing the mean velocity. This is accomplished by making measurements at specified depths using a single point or two-point method. The single point method uses the 0.6-depth below the surface, and the two-point method uses the 0.2 and 0.8-depth below the surface and averaging the results. The single point method is used for stream depths between 0.3 and 2.5 feet. The two-point method is used for stream depths of 2.5 feet and deeper.

Velocity-area discharge measurement error can vary widely depending on the skill of the hydrographer, stream morphology, stream bottom condition, selection of the cross-section measured, and number of measurements performed. Under excellent measurement conditions, the error can be as low as two percent of flow. More realistically, an error of 5 to 8 percent of flow should be expected.

Attachment 1 provides the general procedure for performing velocity-area discharge measurements. The procedure should be supplemented/modified, as necessary, to address project-specific conditions and requirements, and be included in the project work plans.

6.1.2. Weir Plate Method

Current-meter measurements made in shallow depths and low velocities are usually inaccurate, and sometimes impossible to obtain. For these stream conditions, a portable weir plate is a useful device for measuring discharge (if the channel size and geometry allow it's application). Flow rate tables have been developed for various weir shapes and opening sizes including rectangular, trapezoidal, and triangular (V-notch) configurations.

A 90-degree V-notch Weir is most accurate for low flows, about 1 cfs or less, but has similar accuracy to other weir shapes between 1 and 10 cfs. A portable weir plate can be made of 10 to 16 gauge (thickness depending on the weir size) sheet iron that will produce a free-flowing nappe. Temporary framing, and canvas or plastic sheeting, are used to place the weir and direct all of the stream flow across the weir and through the V-notch. A carpenters level is used to make the top of the weir horizontal and the plate plumb. A staff gage for stream head readings is placed (and plumbed) far enough upstream from the weir opening, so that it is not in the drawdown region of the weir (about twice the head reading).

Discharge is computed for 90-degree V-notch Weirs by measuring head from the staff gage and reading flow from a rating table or by use of a formula such as $Q = Ch^{2.48}$; where Q is the discharge, h is measured head, and C is a coefficient of discharge which varies by rating table, (but is approximately 2.49). A rating table is available from the U.S. Bureau of Reclamation. Portable weir plate specifications are available from U.S. Geological Survey, Book 3, Chapter A-8 (page 60, Figure 71). The U. S. Geological Survey provides dimensions for three sizes of 90-degree V-notch Weirs that they describe as, large (flows generally up to 2 cfs), medium (flows generally up to 1 cfs), and small (flows generally up to 0.3 cfs).

Flow accuracy can be within three percent of the total flow for 90-degree V-notch Weirs, if the appropriate weir is selected, properly installed, and not submerged. Weirs should be sized such that the maximum flow to be measured falls within the upper third of the maximum weir capacity. Over-sizing may result in a loss of accuracy at the lower flow ranges.

Attachment 2 provides the general procedure for performing discharge measurements using 90-degree V-notch Weir plates. The procedure should be supplemented/modified, as necessary, to address project-specific conditions and requirements, and be included in the project work plans.

6.1.3. Flume Method

Parshall and trapezoidal flumes are also useful for measuring stream discharge, when depths are shallow and velocities are low. The flume is prefabricated with a converging section, a throat, and a diverging section. The flume is installed level and secured in the channel capturing all of the flow. Discharge is determined by reading head in the upstream throat, usually from a head-gage installed on the side of the flume, and use of a rating table (generally supplied by the manufacturer). Flumes are available in various sizes to accommodate a range of flows and channel sizes. Manufacturers, such as, Plasti-Fab, Inc. of Tualatin, Oregon, can provide prefabricated and portable flumes.

A properly constructed, installed, and operated flume can have an accuracy of two to three percent of the total flow.

Attachment 3 provides the general procedure for performing discharge measurements using Parshall and trapezoidal flumes. The procedure should be supplemented/modified, as necessary, to address project-specific conditions and requirements, and be included in the project work plans.

6.1.4. Volumetric Measurement Method

Volumetric measurements are made when the flow is concentrated and can be diverted into a container. This is the most accurate method for measuring small discharges. Flow is directed by various means (e.g., small PVC pipes) into a calibrated container of known capacity, while time is recorded.

Attachment 4 provides the general procedure for performing discharge measurements using volumetric measurements. The procedure should be supplemented/modified, as necessary, to address project-specific conditions and requirements, and be included in the project work plans.

6.1.5. Surface Float Method

Floats can be used when stream velocities and depths are too low to use a current meter. Both surface and rod floats can be used. A number of floats are distributed across the channel and allowed to move between two stream cross sections, while the time of travel is recorded. Care has to be taken that the floats are not affected by debris in the stream, by touching the bottom, or by wind. The discharge of each partial stream section is computed by the velocity-area calculation and summed to determine the average total discharge.

Float measurements can be made with an accuracy of 10 percent of flow under good conditions, and if care is taken in selecting the stream reach. If a poor reach is selected and too few float runs are made, the error can be as high as 25 percent.

Attachment 5 provides the general procedure for performing discharge measurements using surface floats. The procedure should be supplemented/modified, as necessary, to address project-specific conditions and requirements, and be included in the project work plans.

6.2. Safety Considerations

In addition to following the Shaw E & I approved project Health and Safety Plan, the following safety precautions should be heeded, when performing discharge measurements by stream wading or from a bridge. These precautions are for normal or low stream flow conditions. Stream flow measurements, performed during high flow or flood conditions, are not covered by this SOP. Measurements by stream wading should not be conducted for these conditions. The measurement of streams can be hazardous. Constant vigilance needs to be exercised to avoid the many sources of accidents and injuries.

The safety precautions include, but are not limited to, the following:

- Wear appropriate stream wading boots and waders. Do not wear boots or waders that are too tight (so that they can be slipped out of, if necessary, in case of a fall.
- When wading a stream, always probe the bed ahead with the wading rod and keep your feet well spread apart for better stability. If the depth and stream velocity become too great for safe wading, do not turn around, when the greater area of the front and back of the body is exposed to the current you may be swept downstream. Back out carefully, bracing yourself with the wading rod.
- Wear a personnel flotation device (PFD) when wading deep water (do not wade in fast moving deep water).
- Beware of sand channels where potholes, quicksand, and scour channels can be hazardous.
- Be alert to rapid water rises when wading a stream.
- Be aware of slick steep banks and swampy areas.
- Stay out of streams with partial or thin ice cover and especially of ice-covered streams at the time or incipient breakup.
- Be aware of hazardous or dangerous wildlife that inhabit stream areas.
- Use adequate traffic warning signs and signals, and wear a reflective safety vest when working from a bridge. Take appropriate precautions for fall protection.

Additional site-specific conditions may also need to be identified and appropriately planned for.

6.3. Potential Errors

Errors in stream flow measurements using current meters and floats are the result of poor or insufficient velocity measurements, poor or insufficient depth measurements, and poor cross-sectional area determinations. Open-channel flow is turbulent flow with in-stream velocities varying both across the channel and with depth in the water column. Stream channel morphology, bottom materials, growing vegetation, debris, obstructions (both natural and man-made) contribute to the flow variability.

The hydrographer can reduce the error of velocity-area discharge measurements by:

- Selecting the stream cross-section carefully (look for more uniform flow sections and flow controls)
- Avoiding stream reaches with irregular channel sides and bottoms or unstable banks
- Clearing debris and channel obstructions, if possible, before making measurements
- Maintaining the current-meter in good operating condition and within calibration standards

- Making sufficient velocity and depth measurements (not more than 10 percent [and preferably 5 percent] of the flow [in the vertical and horizontal partial stream sections] should be measured in each partial stream section) not missing the high and low velocity sections
- Not allowing the wading rod to sink into a soft stream bottom
- Making velocity measurements normal to the cross-section (or making the appropriate corrections)
- Measuring velocity at the appropriate depth(s) in the water column (0.6 or 0.2 and 0.8 depth positions)
- Not allowing the hydrographers body to effect flow conditions
- Making measurements during stable stream flow and stage conditions
- Carefully measuring distance across the stream channel
- Carefully determining the cross-sectional area or the stream channel
- Carefully computing discharge through sub areas of the channel cross-section

For flumes or weirs, best accuracy may be obtained by:

- Selecting the appropriate flume or weir shape for the expected flow range
- Carefully installing and leveling flumes and weirs (installed level and all water directed through the flume or weir)
- Allowing the back water to stabilize
- Removing any debris that accumulates in the flume or across the weir
- Carefully placing and plumbing the upstream staff gage

For volumetric measurements, best accuracy may be obtained by:

- Capturing all of the water
- Accurately timing the flow into the container
- Accurately calibrating the container

6.4. Documentation

Documentation of stream discharge measurements, and description of data analysis techniques, should follow appropriate Shaw E & I and project-specific requirements. The documents and/or records should be placed in the project files and include all field forms, notes, logs, calculation sheets, and electronic data files.

6.5. Technical Review

All stream discharge measurement plans and results should undergo technical review. It is also recommended that the technical reviewer provide oversight of the actual field measurements. The technical reviewer should be a person capable of planning, conducting and evaluating stream discharge measurements and measurement programs. The technical reviewer should not have developed the discharge measurement plans or conducted the particular stream discharge measurements to be reviewed. Individuals needing assistance in finding qualified technical reviewers may consult internal Shaw E & I technical listings for experts in conducting stream discharge measurements, or may possibly use an expert outside of Shaw E & I, if necessary.

The technical review, at a minimum, should consider and evaluate the following items:

- Purpose and scope of the stream discharge measurements
- Stream location, morphology, estimated flow
- Number and location of proposed measurement points
- Equipment list
- Current meter calibration
- Safety procedures
- QA/QC procedures
- Planned measurement methodology and field implementation
- Flow rate computational methodology
- Measurement results

Any issues raised during the technical review should be resolved between the reviewer and staff conducting the stream discharge measurements before external (i.e., outside of Shaw E & I) submission of the stream discharge measurements results. The technical review comments and issues, and corresponding resolution should be documented and filed with the project records.

7. ATTACHMENTS

- Attachment 1, General Procedure for Performing Discharge Measurements by the Velocity-Area Method
- Attachment 2, General Procedure for Performing Discharge Measurements Using 90-degree V-notch Weir Plates
- Attachment 3, General Procedure for Performing Discharge Measurements Using Parshall and Trapezoidal Flumes
- Attachment 4, General Procedure for Performing Discharge Measurements Using Volumetric Measurements
- Attachment 5, General Procedure for Performing Discharge Measurements Using Surface Floats

8. FORMS

None; the forms to be used for the stream discharge measurements should be specified in the project work plans.

Attachment - 1

General Procedure for Performing Discharge Measurements by the Velocity-Area Method

The general procedure for measuring streams by the velocity-area method is described below. The method for calculating the discharge is presented in *Techniques of Water-Resources Investigations of the U.S. Geological Survey* "Discharge Measurements at Gaging Stations", Book 3, Chapter A-8 and ASTM D 3858 – 95 (Reapproved 1999) "Standard Test Method for Open-Channel Flow Measurements of Water by Velocity-Area Method".

Equipment:

- Hip boots or waders
- PFD (depending on stream depth and flow velocity)
- Top-setting wading rod
- Stop watch of electronic counter
- Current meter (Price AA or Pygmy depending on expected flow, or other similar meter)
- Tagline
- Metal rods or stakes to secure tagline along stream bank
- Meter rating table
- Field Form
- Clipboard with neck strap

Measurement Procedure:

1. Select a stream reach that best satisfies the following conditions:
   - Straight with parallel velocity streams lines
   - Stable stream bed, free of large rocks, weeds, and protruding obstructions which would create turbulence
   - Flat stream bed profile to eliminate vertical components of flow

   The stream channel can be modified (building dikes or removing debris and rocks) and allowed to stabilize prior to measurements.
2. Select a stream cross section from this reach.
3. String a tagline across the stream at right angles to flow.
4. Measure the stream width.
5. Determine the spacing of the verticals (use about 25 to 30; spaced so that no partial section has more that 10 percent [but ideally 5 percent] of the total discharge).
6. Select the appropriate meter (Price AA for depths of 1.5 feet and greater, or Price pygmy for shallower depths down to 0.3 feet and velocities greater than 0.2 feet per second) and assemble the wading rod, current meter, and electronic counter (or use stop watch); perform a spin-test of

the meter (spin the meter to verify that it is moving freely by noting the duration of the spin and compare to the manufacturers specifications).

7. Set up the appropriate field form and record the stream name, stream stage, start time or measurement, date, exact location on the stream, type of meter and serial number, which side of stream measurements are to start from (LEW, left edge of water or REW, right edge of water while facing downstream), discharge controls.

8. Start the measurements at the first stream section; record the distance from the initial point to the edge of water and determine the stream depth at the partial section (do not allow the rod to sink into soft sediment).

9. Determine the method of velocity measurement (0.6-depth [average depth less than 2.5 feet] or 2-point [0.2 and 0.8-depth from 2.5 feet and deeper] without switching between measurement methods across the section)

10. Compute the meter depth setting and place the meter at the appropriate depth at right angles (or make adjustments by multiplying the velocity by the cosine or the angle to flow) to the cross section, keeping the wading rod vertical.

11. Allow the meter to adjust to the current velocity.

12. Begin measurements by holding the meter into the current and placing it one to three inches downstream of the tagline; stand in a position that least affects the measurement (facing the bank with the flow against the side of the leg and the rod extended about 18 inches from the body).

13. Count the meter rotations for a period of 40-70 seconds (start the counter or use the stop watch; note that the first click is counted as "zero") stopping the count (and timing) on a number given in the meter rating table.

14. Record the number of revolutions and time interval.

15. Move to each of the verticals and repeat procedure; recording the distance from the measurement point to the edge of water, depth, meter depth position, revolutions, and time interval; until the entire cross section has been traversed.

16. Record the end time of the measurements; noting any issues associated with the measurements and expected accuracy of the measurements. Record the final stream stage, noting any changes from the initial conditions.

17. Compute the partial discharges and sum for the total flow across the section and record computations and the results on the appropriate form.

Attachment 2

General Procedure for Performing Discharge Measurements Using 90-Degree V-Notch Weir Plates

The general procedure for measuring streams using a 90-degree V-notch weir plate is described below. A head to discharge conversion (rating) table can be obtained from the U.S. Bureau of Reclamation "Water Measurement Manual".

Equipment:

- 90-degree V-notch weir sized appropriately for the expected flow and channel cross-section
- Carpenters level
- Shovel
- Measuring tape
- Staff gage
- Canvas, sheet plastic
- Sand bags
- Field notebook or form
- Rating table for the weir

Measurement Procedure:

1. Select a weir of the appropriate size for the flow to be measured.
2. Install the weir in the channel, making sure that all of the flow is directed through the weir.
3. Level the weir across the top.
4. Plumb the face to the weir plate.
5. Install the staff gage upstream out of the weir drawdown (within the backwater and at least two times the pool depth upstream).
6. Allow the flow to stabilize through the weir (including backwater).
7. Read upstream stream head from the staff gage by taking multiple readings over several minutes and averaging the results. Record the multiple readings, their corresponding times and the resultant average on the appropriate form(s).
8. Convert head to discharge using the rating table and note on the appropriate form(s)/record(s).

Attachment 3

General Procedure for Performing Discharge Measurements Using Parshall and Trapezoidal Flumes

The general procedure for measuring streams using a Parshall or trapezoidal flume is described below. Head-to-discharge rating tables can be obtained from the flume manufacturer.

Equipment:

- Parshall or trapezoidal flume sized appropriately for the expected flow and channel cross section
- Carpenters level
- Shovel
- Staff gage (usually installed on the flume)
- Canvas, sheet plastic
- Sand bags
- Field notebook or form
- Rating table for the flume

Measurement Procedure:

1. Select a flume of the appropriate size for the flow and channel cross section to be measured.
2. Install the flume in the channel, making sure that all of the flow is directed through the flume.
3. Level the flume bottom, both longitudinally and transversely.
4. Allow the flow to stabilize through the flume.
5. Read upstream stream head from the staff gage by taking several readings over a few minutes and averaging the results. Record the multiple readings, their corresponding times and resultant average on the appropriate form(s).
6. Convert head to discharge using the rating table and note on the appropriate form(s)/record(s).

Attachment 4

General Procedure for Performing Discharge Measurements Using Volumetric Methods

The general procedure for measuring streams using volumetric methods is described below.

Equipment:

- Various lengths and diameters of pipe or troughs
- Various sizes of calibrated containers (calibration can be done by weighing the container with varying amounts of water and noting the depth)
- Shovel
- Canvas, sheet plastic
- Sand bags
- Stop watch
- Field notebook or form
- Calculator

Measurement Procedure:

1. Construct a small dam or diversion in the stream to concentrate the flow.
2. Insert the pipes or troughs into the diversion.
3. Direct the flow into a calibrated container.
4. Measure the time to fill the container and note on the appropriate form(s)/record(s).
5. Compute the discharge (divide the amount of water collected in the container by the time to fill) and note on the appropriate form(s)/record(s).

Attachment 5

General Procedure for Performing Discharge Measurements Using Surface Floats

The general procedure for measuring stream discharge using surface floats is described below.

Equipment:

- Hip boots or waders
- Stop watch
- Floats of various sizes and shapes (wooden discs, partially filled bottles, oranges, weighted rods)
- Tagline
- Metal rods or stakes to secure tagline along stream bank
- Wading rod or similar depth measuring device
- Field Form
- Clipboard with neck strap
- Calculator

Measurement Procedure:

1. Select a straight stream reach with uniform flow.
2. Select two stream cross sections about 20 seconds travel-time apart (actual time of travel will depend on flow velocity).
3. Measure the distance and depth across each cross section.
4. Distribute a number of floats across the stream channel far enough upstream of the first cross-section, so that a constant velocity is reached before timing (make sure that the floats do not touch the channel bottom and are not affected by wind).
5. Note the positions of the floats (distance from bank) as they cross the upstream cross section and record on the appropriate form.
6. Measure the time-of-travel of each float to reach the downstream cross section and record on the appropriate form.
7. Note the position (distance from bank) where each float crosses the downstream cross section and record on the appropriate form.
8. Compute the velocity of each float (distance between each cross-section divided by time-of-travel) and record on the appropriate form.
9. Compute the mean flow velocity in the vertical (float velocity times a coefficient to convert surface velocity to mean velocity of flow; usually 0.85 [the coefficient for rod floats can vary from 0.85 to 1 depending on the shape of the cross-section and velocity distribution]) and record on the appropriate form.
10. Compute the discharge of each partial stream section as defined by the spacing of the floats across the channel (mean velocity times cross-sectional area) and record on the appropriate form.

11. Compute the total discharge by totaling the partial section discharges and record on the appropriate form.